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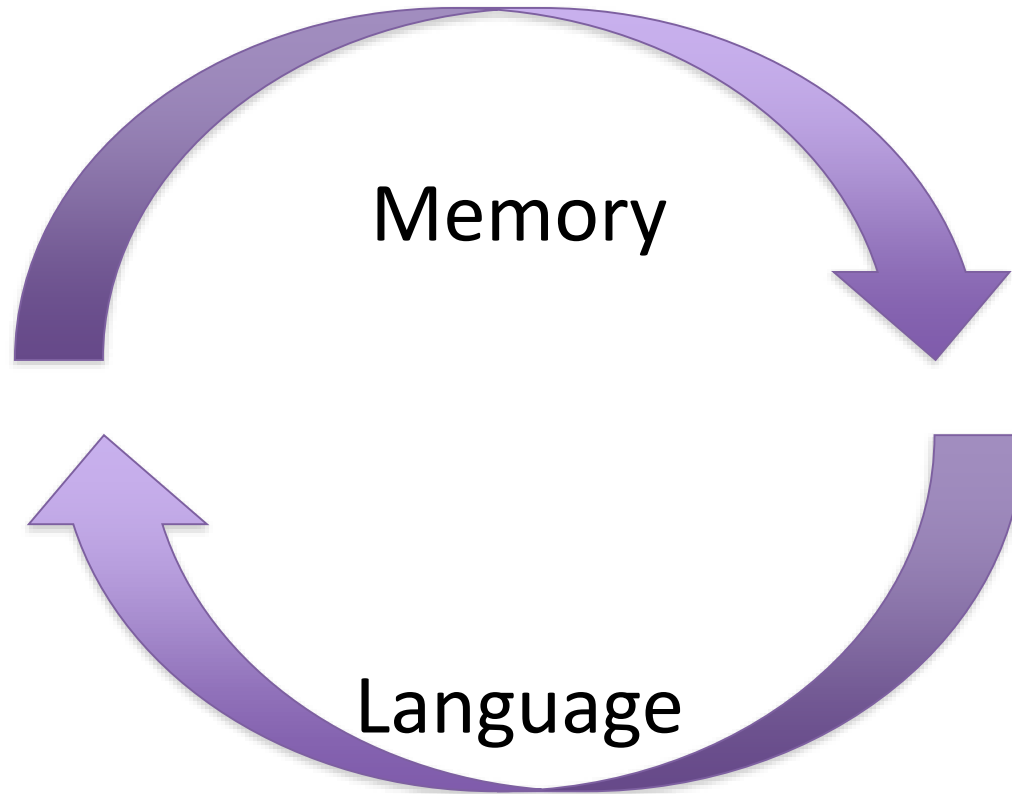# Evidence-based Strategies for Supporting Working Memory during Intervention

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Overview

1. Memory, processing, cognitive load
2. Working memory strategies supporting intervention

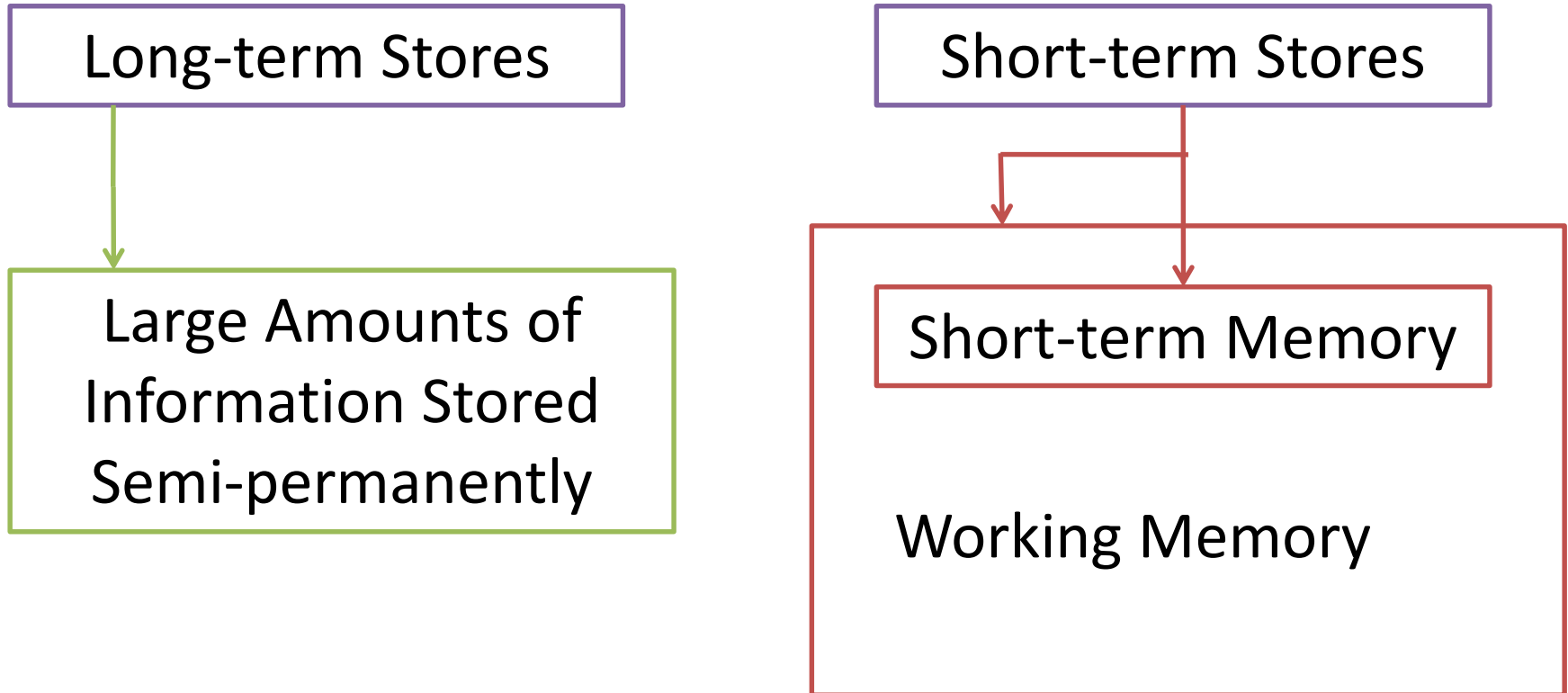# Interconnected Systems

Memory

Language

Many children with language-related difficulties will struggle with memory too

Developmental Language Disorder

- A persistent language problem with a significant impact on everyday social interactions or educational progress
  - with no associated differentiating biomedical condition
- Nature of language impairment varies across individuals but can affect:
  - phonology   - word finding
  - syntax   - pragmatics / language use
  - semantics   - verbal learning & memory

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Bishop et al., 2017

Memory

Long-term Stores

Short-term Stores

Large Amounts of Information Stored Semi-permanently

Short-term Memory

Working Memory

Short-term memory

- Brief encoding and retention of information in the immediate situation

- Limited capacity

- Information decays unless active rehearsal

- Catastrophic loss

STM & Types of Information

- Speech Sound Based (Phonological)
  - *Remembering an unusual word form*
  - Important in word learning
- Visuospatial
  - *Remembering the path back to the Specialist's office from the washroom*

Phonological STM

Visuospatial STM

But we're not usually just trying to remember something….

We're trying to work something out too!

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Our Mental Workspace

- There is no strict line between memory and thought

- We are constantly thinking about the information we're holding in our current focus of attention

  - Reasoning; problem solving; reading/writing; etc.

Working Memory

- Coordinates the work in our mental workspace
- Active monitoring and manipulation of information being held in current focus of attention
- Temporary; limited in capacity
- Catastrophic loss

Working Memory Jobs

1. Storage and processing of information

   - Not just maintenance of material

   - Build temporary relationships

     - Transformation of information

     - Derivation of new information

2. Maintain appropriate information

   - Activate needed information

   - Suppress irrelevant information

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Storage Load

- How much information
  - how close it is to other information trying to be remembered
- How familiar the information is
  - automaticity
  - how easy it is to recall
    - how well information is organized in the brain
- Opportunities for rehearsal

- When trying to hold new information in mind, there won't be much capacity for additional processing activities

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Note the verbal / language demands: Those with poor phonological or vocabulary knowledge will experience a greater storage burden.

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Processing Load

- What is processing?
  - The chemical & electrical signals in the brain that allow you to comprehend your environment & gain knowledge
  - Thought-based activities allowing you to:
    - attend to a stimuli
    - reason, problem-solve
    - recall something
    - associate information in new ways
    - formulate conversational turns
  - Processing tasks vary in signals / thoughts required to complete the task

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Processing Load

- How familiar / novel the thinking routine is
- How complex the thinking routine is
- How many distractions are occurring (& being processed)

- When trying to think creatively & effortfully, there won't be much capacity for maintaining information in mind

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Processing Load

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- How many distrac   ng processed)

- When trying to think cre there won't be much capacity for maintaining information in mind

Note the verbal / language demands: Those who have difficulty putting their thoughts into words will have a greater processing burden.

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Coordinating WM Demands

Storage   Processing

Working Memory

- 3 + 5 =

- What do these letters spell?

- Remember the animals unless they're smaller than a loaf of bread

- How do you feel about working late?

What are you storing?
What are you processing?

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Cognitive Load Theory

- There is a limit to how much new information the brain can process at one time
- There are no known limits to how much information can be stored
  - elements of information can be connected into larger chunks (schemas) making less to store in working memory
  - cognitive/processing load is reduced
- Working memory overload impairs learning
  - well-designed instruction can help maintain a manageable working memory load to support learning
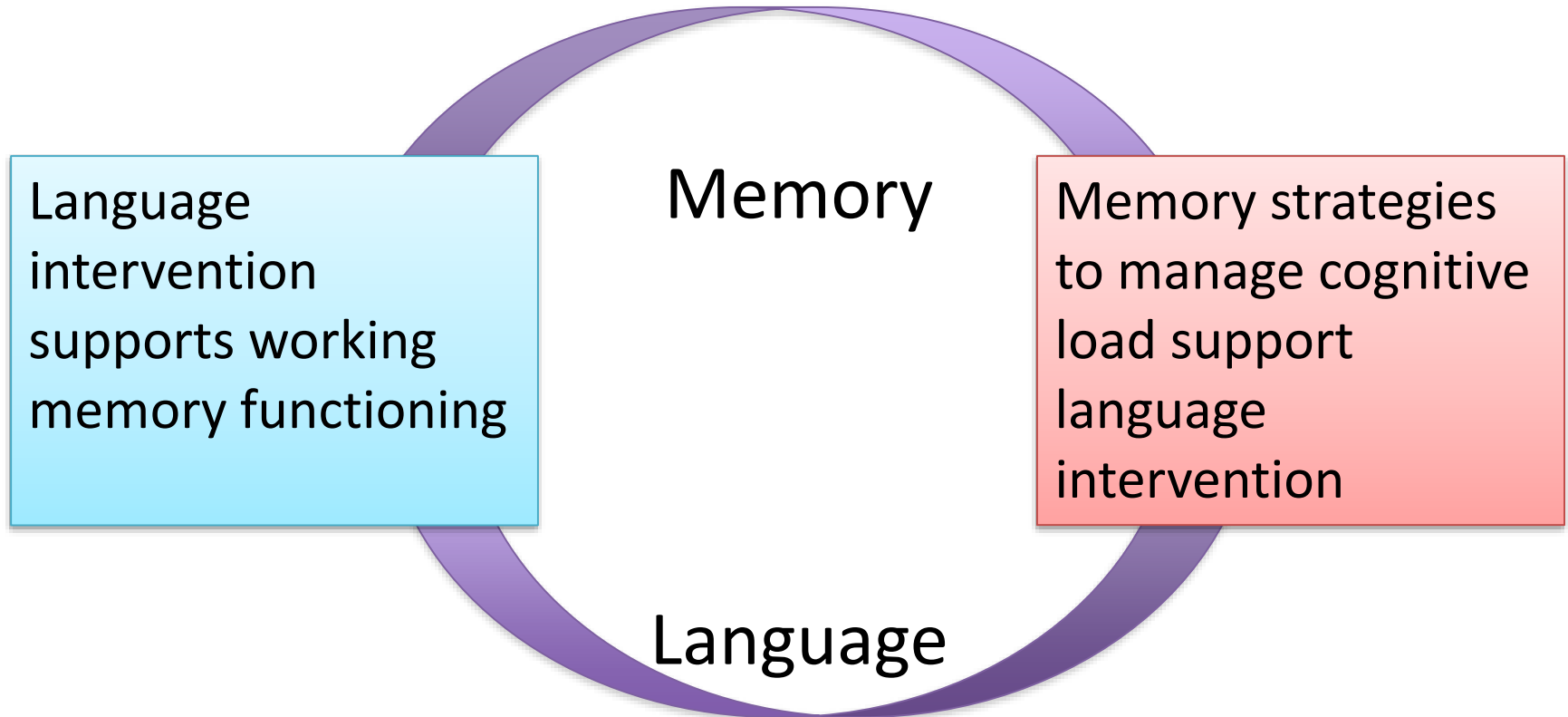
Working Memory Training

- Evidence suggests transfer to closely related tasks only
  - After intensive & consistent work
  - Long-term results are unknown
    - The effect is likely localized to the intervention period, at least to some extent

Melby-Lervåg et al., 2016

Near Transfer

- Broadly speaking, the evidence suggests near transfer
  - for cognitive training
  - even for linguistic training, far transfer is mediated by trained skills

➢ spend your therapy time on knowledge & skills the child needs

Sala & Gobet, 2017; Melby-Lervåg et al., 2020

Interconnected Systems in Intervention

Memory

Language

Language intervention supports working memory functioning

Memory strategies to manage cognitive load support language intervention

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Language Intervention

- Improving language skills will have a positive effect on working memory
  - better word knowledge will reduce storage load
  - more fluid formulations will reduce processing load
  - not a far transfer effect (i.e., we're not increasing WM capacity with language therapy)
  - it's more of a functional change ->
    - increasing the chunk size (reduces storage load)
    - increasing processing efficiency (reduces processing load)
      - > improves WM functioning

Working Memory Strategies

- Storage-related strategies
  - focus on retention of new information
- Processing-related
  - reducing storage load
  - facilitating thinking routines / schema
- General learning principles

➢ Remember: learning a strategy imposes a cognitive load!
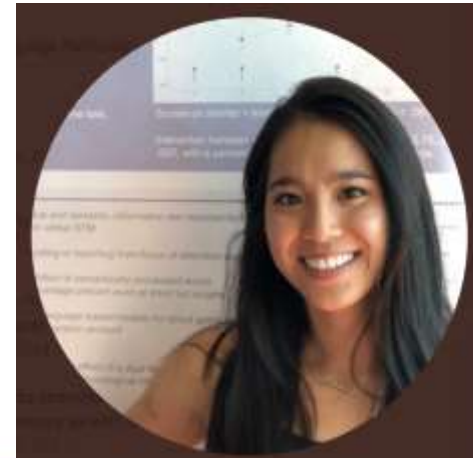
Storage-related Strategies

- Repetition
  - students with language and/or working memory issues will need many, many more repetitions
    - 36 times! (Storkel et al., 2017)
    - 2-3 times more than peers
    - spoken aloud
  - how can the child access more repetitions?
    - review with peer
    - listen to recorded words
    - vocabulary card games
    - auditory bombardment

Storage-related Strategies

- Rehearsal
  - holding information in mind takes cognitive effort
  - decay or 'overwriting' can happen very quickly
    - no support from prior knowledge
    - shift attention to processing activity or distraction
  - rehearsal may need to be explicitly taught
    - restating information immediately
    - repeat rehearsal shifting gradually from spoken aloud to silent (i.e., 'in their head')
  - ask the child about their rehearsal strategies
    - how are you going to remember what I'm telling you?

Storage-related Strategies

- Phonological strategies
  - activities emphasizing phonological structure of a word
    - counting syllables
    - identifying sounds
  - improve phonological representation
  - impose lower working memory demands than semantic strategies
    - semantic connections will need to be taught too, but can be layered in

Storage-related Strategies

- Distributed practice / spaced learning
    - initial memories are fragile
    - spacing out learning episodes support retention
        - relieves working memory in short term
        - encourages effortful retrieval
        - facilitates long-term memory encoding
    - unique learning events re-engages the child
    - engages repeated retrieval
    - when correct responses are supported, correct pathways are reinforced
    - allows for consolidation between practice episodes
    - can promote generalization

Multiple Means of Learning

- Different processes support verbal or visuospatial information retention
  - provide complementary effects rather than increasing cognitive load
- Multiple means promotes high quality representations with connections established broadly across the brain
- Provides alternate means of access and demonstrating learning
- Embodied learning
  - make connections & engage physical movement

Processing-related Strategies

- Connections with long-term memory
    - activating background knowledge
    - word & world knowledge
    - increases activation associated with information & supports retention
    - facilitates chunking of information
    - self-generated connections are most effective

Processing-related Strategies

- Using highly familiar or automatized information
  - allows cognitive capacity for creative thinking
    - e.g., writing a persuasive essay about a sport you know lots about
- Consistent with automatization efforts:
  - fluent word recognition
  - memorized math facts

Processing-related Strategies

- External aids
  - we use these all the time!
  - help your students use them too!
  - alleviate working memory by providing a permanent record (so you don't have to hold in mind)
    - e.g., graphic organizers; key word lists

Processing-related Strategies

- Retrieval practice
  - studying & recalling information increases ease of accessibility and durability of the representation
  - self-testing: challenging yourself to generate the newly learned information on your own
  - better than recognition at supporting learning
    - e.g., students read a text, set it aside, then recall & write down what they remember
  - also increases child's awareness of what they know, which can lead to strategy development & use
  - facilitates consolidation

https://www.cultofpedagogy.com/retrieval-practice/

Processing-related Strategies

- Explicitly teach task steps / schema
  - the 'worked example effect' for **<u>novice</u>** learners
  - unguided learning
    - imposes high working memory load
    - overloaded working memory may not retain successful strategies

    - time spent on unrelated or unsuccessful strategies
    - reinforces these unsuccessful strategies
    - causes frustration
  - fade out guided learning as learning increases

Processing-related Strategies

- Desirable difficulty
  - prolonged use of strategies that provide too much support can deter learning
    - too much repetition
    - too much reliance on worked examples
  - prolonged struggling with a task that is too hard or overloads memory can deter learning
    - frustration
  - desirable difficulty imposes just enough challenge to engage processing fully but doesn't overload

Processing-related Strategies

- Keep focused on the task
  - interference deters learning
  - manage the amount of information
    - avoid distractions
    - unnecessary or redundant information can impede learning
    - pictures are helpful provided they are relevant, add something to the information, and are integrated into the instruction

Willingham, 2017

General Learning Principles

- Arousal & attitude matter
  - alert, engaged, motivated, ready
- Intentionality matters
  - focused on task, making effort, consistent feedback
- Salience matters
  - repeated exposure to same stimuli reduces activation
  - sufficiently noticeable; multidimensional
  - engages motivation & emotions
- Intensity matters
  - sufficient training required

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Katz & Dack (2012)

General Learning Principles

- Cognitive distance matters
  - not all neuroplastic responses are alike (limits generalizability?)
  - sufficiently similar to real life applications
- Cognitive miserliness matters
  - tendency to avoid cognitive expenditures
  - prefer to see (reinterpret) things as familiar
  - complex thinking requires cognitive effort
  - consider cognitive fatigue
    - interleave tasks of differing cognitive demands

If you are…

- Improving language knowledge
  - sufficient intensity
  - high quality representations
  - well-connected to existing knowledge
- Managing working memory load to support learning
- Teaching working memory strategies for the child to use

then you are…

Addressing the working memory needs of your student

Thank you!

- To contact me…
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References

- Cognitive load theory: Research that teachers really need to understand. https://education.nsw.gov.au/about-us/educational-data/cese/publications/literature-reviews/cognitive-load-theory#:~:text=Cognitive%20load%20theory%20indicates%20that,of%20what%20they%20must%20learn.

- Cognitive science approaches in the classroom: A review of the evidence. https://educationendowmentfoundation.org.uk/education-evidence/evidence-reviews/cognitive-science-approaches-in-the-classroom

- Melby-Lervåg et al. (2016) Working memory training does not improve performance on measures of intelligence or other measures of 'far transfer': evidence from a meta-analytic review. Perspect Psychol Sci, 11, 512-34.

- Melby-Lervåg et al. (2020) Disentangling the far transfer of language cmoprehension gains using latent mediation models. Dev Sci, 23, e12929.

- Pham & Archibald (2019) Avoiding working memory overload in students with learning disabilities. https://www.ldatschool.ca/working-memory-overload/

- Sala & Gobet (2017) Does far transfer exist? Negative evidence from chess, music, and working memory training. Curr Dir Psychol Sci, 26, 515-520.

- Willingham, D (2017) Ask the cognitive scients: Do manipulatives help students learn? American Educator, Fall 2017, 25-40. https://www.aft.org/sites/default/files/periodicals/ae_fall2017_willingham.pdf

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